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Professional paper

INTRODUCING OF THE FIBERGLASS ROCKBOLTS WITH TWO-COMPONENT RESIN IN THE "RUDNIK" MINE TECHNOLOGICAL PROCESS

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Abstract: This paper presents, in brief, principles of the underground rooms supporting by the fiberglass rockbollts, in combination with the two-compound mixture. This type of rockbolts was succesufully introduced in the "Rudnik" mine technological process, with excellent results related to the application, installing, breaking load and, especeally, for the employements working safety.
Knowing working conditions in the selected part of the "Rudnik" underground mine, as well as defined mining method, the conclusion that fiberglass rockbolts with two-component resin are most suitable for application, was made.

Key words: fiberglass rockbolts, "Rudnik" mine, two-component mixture - resin

1. INTRODUCTION

Orebody P2 (mining structure "Prlovi") is situated in the north-western part of the "Rudnik" deposit. This is the largest orebody of this structure, and it is situated partly just under the surface, and partly outcrops, which is the reason for oxidation of the large part of the sulfide ore body. With the aim to enable underground excavation of the sulfide core of this orebody, an appropriate mining design, wich including appliance of the cut-and-fill mining method with diesel powered machines, was made (technical dokumentation of ″Rudnik″ mine and Mining Institute).

Based on fact that underground rooms, especially those which are made in the ore, must be supported (occasionally or sistematically), and later to be collapsed due to the stope formating, it is decided that fiberglass rockbolts with two-component mixture-resin has to be applied in these uderground rooms, and in the later formatted stopes. This will, after blasting the underground room roof, allow continuous and safe loading of the blasted material, wich will be impossible by using the steel rockbolts. To make this decision technically and economically justified, it was necessary to perform appropriate testings of these type of fiberglass rockbolts in the concrete location, which was including supervising of the drilling parameters, installing process, and pull-out tests of the chosen type of rockbolts and accessories.

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2. THE PRINCIPLES OF FUNCTION OF ROCKBOLTS WITH TWO-COMPONENT MIXTURE - RESIN

Rockbolts, which are tied with the rock mass by the two-component resin (AT rockbolts) are part of the group of rockbolts which are bear throughout its whole lenght, e.c. borehole lenght. The strenght of the system depends of two-component resin strenght and connection strenght. High bonding strenght (rockbolt-resin-rock) providing strong resistance to shear. Principle of the rockbolt function is direct confrontation to the shear in the roof or side (pillar) of the room due to restricting of the roof movements, so the shearing strenght of the direct roof or side of the underground room is significally increasing (Tokalić, 2008).

Basic principle of operation of two-component (polymer or epoxide) resin rockbolts is joining of the lower layers of the hanging wall (roof) with upper, undisturbed layers, together with partial filling cracks with resin, what convert layers into a solid beam construction. Some authors believe that this kind of support reinforces the rock mass analog reinforcement in reinforced concrete (Marasová et al. 2010).

AT rockbolts act differently in soft, medium hard and hard rocks due to the different cohesion or shear strength between the anchor and mixtures, as well as between the mixture and the walls well, and because of the different characteristics of the materials mentioned three elements.

In conditions of great stress and weaker rocks in the roof, which is common in underground mines, it is necessary to implement an adequate system of reinforcement in the hanging wall (roof), for efficient active influence on the shear, which will, for sure, cause a movements in the roof, which causes hanging wall collapse (Tokalić, 2008).

3. INSTALLATION AND TESTING OF ROCKBOLTS

Installation and testing of fiberglass rockbolts anchor with two-component mixture (resin) in the mine "Rudnik" were carried out from 09. to 12.12.2009. In this period, a team of technical personnel of the "Rudnik" mine, experts from Mining Institute Ltd. and representatives of manufacturers of rock bolts carried out an inspection and verification of the prepared materials and required equipment, determine the location of the test - preparatory work for the excavation of the ore body P2 - drilled boreholes and installed anchors for testing. Then they installed rockbolts in different time periods tested by pulling-out.

Fiberglass mounting bolts for the testing is done as follows (Mining Institut, 2009): The drilled hole and cleaned the length of 1.6 m is placed a certain number of cartridges two-part mixture. Then, the cartridges must easy be pushed into the bottom of the borehole by the rockbolt. On the free end of the rockbolt pneumathic rotary drill with a special key that is placed on the threaded end of the rockbolt. The machine runs with constant rotation of the rockbolt is pushed to the end of the borehole. On that occasion, pointed front part of the anchor breaks the plastic cover cartridge so there is a mixing of the components, gelling and bounding. The whole process of installation, and rockbolt rotation takes about ten seconds. As soon as the mixture bound, stops the

possibility of rotating rockbolt. The principle of rockbolt mounting is shown in Figure 1.

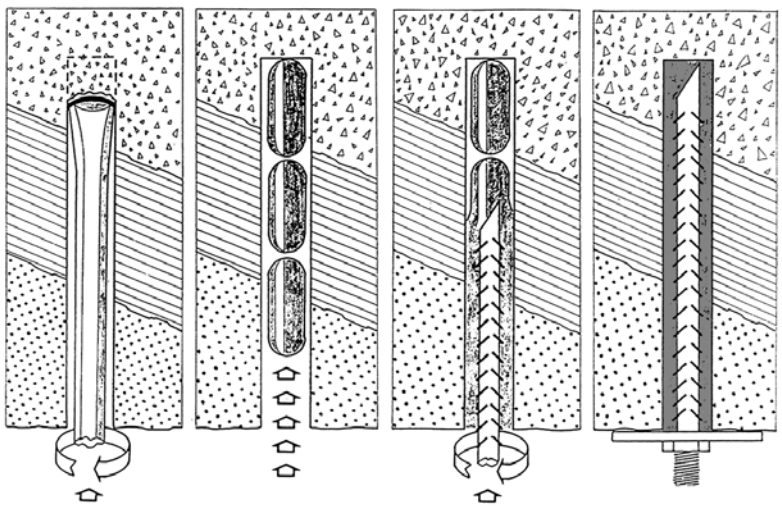

Figure 1 – Mounting bolts with two-component mixture-resin

Rockbolts type Fiberglass bolt GRP K60, with diameter d = 27 mm and l = 1800 mm long, with support plate of fiberglass GRP Plate R=200 mm, with nut **GRP Nut** manufactured by FIREP, Switzerland and fast-bonding two-component mixture-resin type Lokset 28x250 mm HS Fast (fast bonding - setting time t = 13-18 s) and Lokset resin 28x600 mm HS Slow (slow bonding – bonding time t = 70-200 s), manufacturer MINOVA Ekochem, Poland (Figure 2) were installed in the boreholes. Rockbolts and capsules have all necessary international certificates (Atlas Copco, 2009).

Figure 2 - Types of two-component mixture capsule manufactured by ″Minova″

Rockbolts have been tested by the manufacturer representatives, in an appropriate methodology, to break tension. Research was conducted in conditions of the "Rudnik" mine, in the P2 orebody stope, at a temperature of $T \approx 15°C$.

Rock bolts have been built in the diameter $d = 34$ mm boreholes, which are drilled with rotary hammer type AC BBD-90/91W ("Panther"), equipped with drill steel length $l = 1600$ mm. Fiberglass rockbolts are placed in the side and the roof of the excavation drift (Figure 3), whose location is selected by the technical personnel of the “Rudnik” mine and experts from the Mining Institute Ltd. Initially, the resin capsule are placed in the boreholes, fast bonding (resin type Lokset 28x250 mm HS fast) the first, and then slow-bonding (Lokset resin 28x600 mm Slow HS). This means that the rockbolts are bonding to rock mass with two cartridges – slow-bonding (600 mm length) and fast-bonding (250 mm), with overall length of 850 mm. In this way, the empty space between the borehole wall and rock bolt is fully complied and filled with resin. In this way, the bonding, and bearing of rockbolts for rock mass over the full lenght of rock bolt bar, is achieved.

After that, rockbolts mounting, using the adapter mounted on the rotary hammer, was done. The average time for placing was max. $t = 30$ s. After installing and setting resin capsules, they are now "pulling out" the rockbolts, due to check the rockbolt capacity. Loading capacity of rockbolts was measured by the hydraulic cylinder, so called "pull tester". First, we made the determination of rockbolts tensile strength, and then we check the properties of tear sternght of the fiberglass rockbolts.

Figure 3 - Mounting of the fiberglass rockbolt into the excavation drift side wall

During "pulling-out" nut bolts broke during the effect of tension - the pressure of $p = 188$ bar ($F = 86$ kN) and just broke the rockbolt of the force-tightening pressure of $p = 250$ bar, which is equivalent to the value of force of $F = 116.5$ kN. Rockbolt breaking point was the end of the rockbolt, outside the borehole. There was no drawing of the rockbolts from the well (Figure 4)

Figure 4 - Broken fiberglass rockbolt

Using the coefficient of safety $\nu = 1.5$, it was concluded that the investigated fiberglass rockbolts can be used to support the stopes and underground rooms in the "Rudnik" mine, where, by the appropriate calculation, a bearing capacity of min. $F = 77$ kN, is required (Mining Institut, 2009).

As noted, fiberglass rockbolts with two-component mixture - resin are installed in excavated drifts from which later are to be formated stopes, where the working environment is disturbed by cracks and faults, and where there is a potential risk of falling material from the stope roof. Currently, in the "Rudnik" mine, about 300 pieces of fiberglass rockbolts with two-component mixture (resin) per month has been installed. Some excavated area of ~200 m^2 are fully secured by this type of support, with excellent results in terms of stability and security in work. In special cases, where the separation of smaller pieces of material from the roof is observed, the rockbolts are mounted in combination with steel mesh, shown in Figure 5.

Figure 5 - Rockbolts mounted in combination with steel mesh

4. CONCLUSION

In order to determine the exact bearing capacity of the fiberglass rockbolts, a length of rockbolts bonded with two-compound mixture-resin, when the pull–out machine start to pulling the rockbolt out of the hole, must be determined before breaking the rockbolt bar.

Because during pulling-out test, the rock bolt breaks before it starts to be pulled-out from the borehole, it is not possible to determine the exact rockbolt bearing capacity. In such cases, the bearing capacity of fiberglass rockbolts with a two-component mixture, we must adopt the breakout force on the end of fiberglass rockbolt rod. Nominal rockbolt load is greater, and since it could not be demonstrated in field testing for any necessary calculations the carriage bolts $F = 77$ kN (breakout force of rockbolts $F = 116.5$ kN, with the appliance of safety coefficient of $\nu = 1.5$) was adopted.

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REFERENCES

[1] Tokalić R., [2008]: *Modeliranje kriterijuma za izbor racionalne tehnologije izrade podzemnih prostorija*, Doktorska disertacija, Rudarsko-geološki fakultet, Beograd.

[2] Marasová D., Taraba V., Grendel P., [2010]: *Legislative and its requirements to safety of tunnels*, Acta Montanistica Slovaca, Vol. 15, Special issue 1/2010, Košice, p.9-13.

[3] [2009]: *Izveštaj o ispitivanju sidara sidara Fiberglass bolt GRP K60 sa dvokomponentnom smešom - smolom Lokset*, Rudarski institut d.o.o., Beograd.

[4] [2009]: *Testiranje Swellex i Fiberglass ankera na rudniku "Rudnik" u periodu 09.12.-10.12.2009.*, Izveštaj br. 09/12, Atlas Copco a.d., Beograd.

[5] Tehnička dokumentacija rudnika ″Rudnik″, Rudnik.

[6] Tehnička dokumentacija Rudarskog instituta d.o.o., Beograd.